

## 7 Summary and Recommendations

During the course of the studies to match MOM4, om1 with MOM3 solutions, several items surfaced that contributed to the initial differences that were observed between the two model solutions.

- The Neutral Physics tapering method
- Quicker tracer advection mask
- Topography/Geography
- Bottom friction
- Implementation of horizontal diffusion coefficients
- Implementation of vertical diffusion coefficients
- Bipolar North Pole
- Barotropic Solver

Swathi discovered that one of the major sources of discrepancies was the method for tapering diagonal pieces of the horizontal flux components in regions where the slopes of the neutral direction are steep. MOM4 was originally designed with a tanh taper (*Danabasoglu and McWilliams, 1995*), but MOM3 was designed with a quadratic GKW taper (*Gerdes, Köberle and Willebrand, 1991*). Modifications were made by Steve Griffies to the MOM4 code to “re-implement” the GKW taper. It is recommended that the GKW taper is used in MOM4 for consistency with the MOM3-OCMIP2 model suite.

Anand had also suspected that implementing quicker using a MOM3-type mask would further resolve differences between the models, as MOM4 used a more upwind advection scheme type mask which employs a “ghost cell” at the boundaries. The MOM3-type mask defaults to a 2nd order advection scheme (a.k.a. “centered”) at the boundaries. It is recommended that quicker, and especially quicker with a MOM3-type mask, should be used in MOM4 for consistency with the MOM3-OCMIP2 model suite.

Swathi’s more idealized experiments showed that when topography/geography is the same in both models, there is essentially no difference between the model solutions. In my “Baseline” run, it was noted that in MOM4 there were some differences in the topography and geography in the northwest Pacific basin. These topography and geography differences caused some large, though somewhat isolated differences between the solutions in the North Pacific. The addition of Japan in MOM4 is a more realistic representation of the geography/topography, but can be an additional source of MOM4,MOM3 solution divergence of an unknown quantity.

The use of options `-bering_friction` and `-linear_friction` in MOM3 changes the way bottom friction is specified. Essentially `-bering_friction` turns off bottom friction everywhere except six grid cells in the Bering Straits. The `-linear_friction` option changes the bottom momentum flux from a quadratic formulation to a linear formulation. It is recommended that `cdbot` should be

set equal to zero in MOM4.

The use of the horizontal diffusion coefficients in the calculation of the tracer diffusive flux tendencies across the eastern and northern tracer cell was found to be set by `ah` in MOM3 and `ahsurf` and `ahback` in MOM4 when `surflayermix` is on. It is not recommended to use `surflayermix`, but one should be aware that the default setting is `.true..` If this option is still desired some code changes in MOM4 are required to make this option consistent with its use in MOM3.

Vertical diffusion coefficients also require some careful attention. Misleading printout was found for MOM3, where vertical diffusion coefficients are said to be parameterized solely by the Bryan-Lewis coefficients (when `constvmix` is on), but this is not the case. Even when `constvmix` is on, vertical diffusion is specified by Bryan-Lewis and `kappa_h`. This sum matches what is used in MOM4. There remains a difference between MOM3 and MOM4 in convectively unstable regions where enhanced vertical diffusion is employed to correct the problem. MOM4 uses a `diff_cbt_limit` as the chosen “enhanced” vertical diffusion value. This switch is not performed in MOM3. It is therefore recommended that the `diff_cbt_limit` in MOM4 be set equal to the value used for `kappa_h` for consistency between the MOM3 and MOM4 solutions.

The tripolar grid is estimated to cause the largest errors in the upper 500 m. For temperature and salinity, the differences between MOM4 and MOM3 global averages are as much as 0.18 °C and 0.017 psu. The Arctic error essentially goes to zero below 500 m.

By process of elimination, the remaining differences are likely due to the barotropic solver- the interaction of the free surface with the time-varying surface forcing. The free surface in MOM4 would add higher frequency surface waves that are normally filtered out by the rigid lid. The phase speeds of surface waves that already exist in the rigid lid case are also altered. The strength and structure of geostrophic currents can also be affected. The RMS Error in the Neutral Physics MOM4 model is about 0.25 °C and 0.025 psu (excluding the surface box value).